

# PATENT COOPERATION TREATY

From the  
INTERNATIONAL SEARCHING AUTHORITY

To:  
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# PCT

## WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43bis.1)

Applicant's or agent's file reference 089-0008-WO		Date of mailing (day/month/year) <b>05 JAN 2007</b> <b>FOR FURTHER ACTION</b> See paragraph 2 below
International application No. PCT/US05/03100	International filing date (day/month/year) 20 January 2005 (20.01.2005)	Priority date (day/month/year) 23 January 2004 (23.01.2004)
International Patent Classification (IPC) or both national classification and IPC IPC: Please See Continuation Sheet USPC: 62/259.2,3,2,118;165/80.3,80.4,80.5;361/699,701		
Applicant NANOCOOLERS, INC.		

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

### 2. FURTHER ACTION

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.  
For further options, see Form PCT/ISA/220.

3. For further details, see notes to Form PCT/ISA/220.

Name and mailing address of the ISA/ US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450 Alexandria, Virginia 22313-1450 Facsimile No. (571) 273-3201	Date of completion of this opinion 21 September 2006 (21.09.2006)	Authorized officer Cheryl Tyler <i>T.A. Solola</i> Telephone No. (571) 272-3750
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Form PCT/ISA/237 (cover sheet) (April 2005)

**WRITTEN OPINION OF THE  
INTERNATIONAL SEARCHING AUTHORITY**

International application No.

PCT/US05/03100

**Box No. I Basis of this opinion**

1. With regard to the language, this opinion has been established on the basis of:

- ☒ the international application in the language in which it was filed
- ☐ a translation of the international application into \_\_\_\_\_, which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

2. With regard to any nucleotide and/or amino acid sequence disclosed in the international application and necessary to the claimed invention, this opinion has been established on the basis of:

a. type of material

- ☐ a sequence listing
- ☐ table(s) related to the sequence listing

b. format of material

- ☐ on paper
- ☐ in electronic form

c. time of filing/furnishing

- ☐ contained in the international application as filed.
- ☐ filed together with the international application in electronic form.
- ☐ furnished subsequently to this Authority for the purposes of search.

3. ☐ In addition, in the case that more than one version or copy of a sequence listing and/or table(s) relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

4. Additional comments:

**WRITTEN OPINION OF THE  
INTERNATIONAL SEARCHING AUTHORITY**

International application No.  
PCT/US05/03100

**Box No. V Reasoned statement under Rule 43 bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

**1. Statement**

Novelty (N)

Claims 4, 9-21, 25 and 26 YES

Claims 1-3, 5-8 and 22-24 NO

Inventive step (IS)

Claims 19 and 25 YES

Claims 1-18, 20-24 and 26 NO

Industrial applicability (IA)

Claims 1-26 YES

Claims NONE NO

**2. Citations and explanations:**

Please See Continuation Sheet

WRITTEN OPINION OF THE  
INTERNATIONAL SEARCHING AUTHORITY

International application No.  
PCT/US05/03100

Supplemental Box

In case the space in any of the preceding boxes is not sufficient.

Continuation of IPC:

F25B 21/02( 2006.01);F25D 17/02( 2006.01);23/12( 2006.01);F28F 7/00( 2006.01);H05K 7/20( 2006.01)

V. 2. Citations and Explanations:

Claims 1-3, 5-8 and 22-24 lack novelty under PCT Article 33(2) as being anticipated by Ghoshal et al. ('861)

Regarding claims 1-3 and 5-8, Ghoshal et al. ('861) disclose:

- a pathway (703 - conduit) for transport of a liquid metal thermal transfer fluid, the pathway including a portion in close thermal communication with the high power density device (see col. 8, lines 42-47);
- at least one electromagnetic pump (707 - electromagnetic pump) for motivating flow of the liquid metal thermal transfer fluid through the liquid metal thermal transfer pathway away from and back to the high power density device (see col. 8, lines 46-49; Figure 7);
- wherein the high power density device is located in a folding device (see col. 9, lines 24-34);
- wherein at least a portion of the liquid metal thermal transfer pathway traverses a bend in the folding device (see col. 9, lines 24-34);
- wherein the bend traversing portion of the liquid metal thermal transfer pathway includes a flexible conduit (see col. 9, lines 24-34);
- wherein the bend traversing portion of the liquid metal thermal transfer pathway includes a hinge that defines an integrated conduit therethrough (see col. 4, lines 59-65; col. 9, lines 24-34);
- the liquid metal thermal transfer fluid (see col. 8, lines 43-47);
- wherein the pathway portion in close thermal communication with the high power density device includes a solid-fluid heat exchanger (701 - solid-fluid heat exchanger; Figure 7);
- wherein the pathway portion in close thermal communication with the high power density device includes a liquid metal chamber (705 - fluid-fluid heat exchanger) that allows direct thermal contact between the high power density device and the liquid metal (as seen in Figure 7);
- a heat sink (719 - heat sink) separated from the high power density device by a heat transfer path (717 - conduit) that includes the bend traversing portion of the liquid metal thermal transfer pathway (as seen in Figure 7).

Regarding claims 22-24, Ghoshal et al. disclose a method comprising:

- transferring heat from the high power density device to a liquid metal thermal transfer fluid (see col. 8, line 42 - col. 9, line 5);
- motivating flow of the liquid metal thermal transfer fluid away from and back to the high power density device in a closed cycle fluid pathway (703 - conduit; col. 8, line 42 - col. 9, line 5; Figure 7) that traverses a bend in a folding device (see col. 9, lines 24-34);
- wherein the bend traversing portion of the closed cycle fluid pathway includes a flexible conduit portion (see col. 9, lines 24-34);
- wherein the bend traversing portion of the closed cycle fluid pathway includes a hinge that defines an integrated conduit therethrough (see col. 4, lines 59-65; col. 9, lines 24-34).

Form PCT/ISA/237 (Supplemental Box) (April 2005)

WRITTEN OPINION OF THE  
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In case the space in any of the preceding boxes is not sufficient.

Claims 4, 9-21 and 26 lack an inventive step under PCT Article 33(3) as being obvious over Ghoshal et al. ('861).

Regarding claim 4, Ghoshal et al. ('861) disclose:

- a pipe (703 - conduit);
- a heat exchanger (701, 705 -solid-fluid heat exchanger, fluid-fluid heat exchanger) coupled to transfer heat between the liquid metal thermal transfer fluid and the pipe (see col. 8, lines 43 - col. 9, line 5; Figure 7).

Regarding claims 9-15, Ghoshal et al. ('861) disclose:

- a pathway (as seen in Figure 7) for transport of a liquid metal thermal transfer fluid, the pathway including a portion in close thermal communication with a pipe (703 - conduit);
- at least one electromagnetic pump (707 - electromagnetic pump) for motivating flow of the liquid metal thermal transfer fluid through the pathway away from and back to the pipe (see col. 8, line 43 - col. 9, line 5; Figure 7);
- wherein the pathway for transport of the liquid metal thermal transfer fluid and the pipe together define a heat transfer path away from the high power density device (see col. 8, line 43 - col. 9, line 5; Figure 7);
- wherein the high power density device is located in a folding device (see col. 9, line 24-34);
- wherein at least a portion of the liquid metal thermal transfer pathway traverses a bend in the folding device (see col. 9, lines 24-34);
- wherein the bend traversing portion of the liquid metal thermal transfer pathway includes a flexible conduit (see col. 9, lines 24-34);
- wherein the bend traversing portion of the liquid metal thermal transfer pathway includes a hinge that defines an integrated conduit therethrough (see col. 4, lines 59-65; col. 9, lines 24-34);
- wherein the liquid metal thermal transfer pathway includes a portion in close thermal communication with the high power density device (see col. 8, lines 43-47; Figure 7);
- wherein at least a portion of the liquid metal thermal transfer pathway is formed using a flexible conduit (see col. 9, lines 24-34);
- the liquid metal thermal transfer fluid (see col. 8, lines 43-47).

Regarding claims 16-21, Ghoshal et al. ('861) disclose a method comprising:

- transferring heat from the high power density device to a liquid metal thermal transfer fluid (see col. 8, line 62 - col. 9, line 5);
- motivating flow (707 - electromagnetic pump) of the liquid metal thermal transfer fluid away from and back to the high power density device in a closed cycle fluid pathway (703 - conduit) (see col. 8, line 43 - col. 9, line 5; Figure 7);
- transferring heat from the liquid metal thermal transfer fluid flow to a pipe (see col. 8, line 62 - col. 9, line 5);
- transporting the liquid metal thermal transfer fluid through a flexible conduit portion of the closed cycle fluid pathway (see col. 9, lines 24-34);
- transporting the liquid metal thermal transfer fluid through a bend traversing portion of the closed cycle fluid pathway (see col. 9, lines 24-34; Figure 7);
- wherein the bend traversing portion of the closed cycle fluid pathway includes a flexible conduit portion (see col. 9, lines 24-34);
- wherein the bend traversing portion of the closed cycle fluid pathway includes a hinge that defines an integrated conduit therethrough (see col. 4, lines 59-65; col. 9, lines 24-34).

Regarding claim 26, Ghoshal et al. ('861) disclose a method comprising:

- transferring heat from the liquid metal thermal transfer fluid flow to a pipe (see col. 8, line 43 - col. 9, line 5).

Ghoshal et al. ('861) do not expressly disclose:

- a heat pipe.

Ghoshal et al. ('861) further teach that it is well known in the art that heat pipes are used to extract heat from high power density devices dissipate the heat at another location (see col. 1, lines 54 - col. 2, line 5). Ghoshal et al. ('861) further disclose forced fluid cooling is an attractive option to cooling HPDDs. Further disclosed is that by circulating the forced fluid through the HPDD, the heat from the HPDD is carried away and dissipated at a sink placed at a distance (see col. 2, lines 21-36).

Regarding claims 4, 9 and 16, in view of this teaching, it would have been obvious to one of ordinary skill in the art to provide the system of Ghoshal et al. ('861) with the claimed heat pipe, in cooperation with the existing electromagnetic pump, as a means of transferring heat away from the high power density device (HPDD) because the heat pipe would allow for effective removal of the excessive temperature buildup that is generated by HPDDs through a means of forced fluid flow, thus decreasing the number of malfunctions, breakdowns and problems associated with interface resistance that occur in HPDDs.

Claims 19 and 25 meet the criteria set out in PCT Article 33(2)-(3), because the prior art does not teach or fairly suggest increasing and decreasing the bend of the pathway that the liquid metal flowing through.

Claims 1-26 meet the criteria set out in PCT Article 33(4), and thus have industrial applicability because the subject matter claimed can be made or used in industry.

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- ☐ a sequence listing
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**1. Statement**

Novelty (N)

Claims 4, 9-21, 25 and 26 YES

Claims 1-3, 5-8 and 22-24 NO

Inventive step (IS)

Claims 19 and 25 YES

Claims 1-18, 20-24 and 26 NO

Industrial applicability (IA)

Claims 1-26 YES

Claims NONE NO

**2. Citations and explanations:**

Please See Continuation Sheet

WRITTEN OPINION OF THE  
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Supplemental Box  
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V. 2. Citations and Explanations:

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Regarding claims 1-3 and 5-8, Ghoshal et al. ('861) disclose:

- a pathway (703 - conduit) for transport of a liquid metal thermal transfer fluid, the pathway including a portion in close thermal communication with the high power density device (see col. 8, lines 42-47);
- at least one electromagnetic pump (707 - electromagnetic pump) for motivating flow of the liquid metal thermal transfer fluid through the liquid metal thermal transfer pathway away from and back to the high power density device (see col. 8, lines 46-49; Figure 7);
- wherein the high power density device is located in a folding device (see col. 9, lines 24-34);
- wherein at least a portion of the liquid metal thermal transfer pathway traverses a bend in the folding device (see col. 9, lines 24-34);
- wherein the bend traversing portion of the liquid metal thermal transfer pathway includes a flexible conduit (see col. 9, lines 24-34);
- wherein the bend traversing portion of the liquid metal thermal transfer pathway includes a hinge that defines an integrated conduit therethrough (see col. 4, lines 59-65; col. 9, lines 24-34);
- the liquid metal thermal transfer fluid (see col. 8, lines 43-47);
- wherein the pathway portion in close thermal communication with the high power density device includes a solid-fluid heat exchanger (701 - solid-fluid heat exchanger; Figure 7);
- wherein the pathway portion in close thermal communication with the high power density device includes a liquid metal chamber (705 - fluid-fluid heat exchanger) that allows direct thermal contact between the high power density device and the liquid metal (as seen in Figure 7);
- a heat sink (719 - heat sink) separated from the high power density device by a heat transfer path (717 - conduit) that includes the bend traversing portion of the liquid metal thermal transfer pathway (as seen in Figure 7).

Regarding claims 22-24, Ghoshal et al. disclose a method comprising:

- transferring heat from the high power density device to a liquid metal thermal transfer fluid (see col. 8, line 42 - col. 9, line 5);
- motivating flow of the liquid metal thermal transfer fluid away from and back to the high power density device in a closed cycle fluid pathway (703 - conduit; col. 8, line 42 - col. 9, line 5; Figure 7) that traverses a bend in a folding device (see col. 9, lines 24-34);
- wherein the bend traversing portion of the closed cycle fluid pathway includes a flexible conduit portion (see col. 9, lines 24-34);
- wherein the bend traversing portion of the closed cycle fluid pathway includes a hinge that defines an integrated conduit therethrough (see col. 4, lines 59-65; col. 9, lines 24-34).

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Claims 4, 9-21 and 26 lack an inventive step under PCT Article 33(3) as being obvious over Ghoshal et al. ('861).

Regarding claim 4, Ghoshal et al. ('861) disclose:

- a pipe (703 - conduit);
- a heat exchanger (701, 705 - solid-fluid heat exchanger, fluid-fluid heat exchanger) coupled to transfer heat between the liquid metal thermal transfer fluid and the pipe (see col. 8, lines 43 - col. 9, line 5; Figure 7).

Regarding claims 9-15, Ghoshal et al. ('861) disclose:

- a pathway (as seen in Figure 7) for transport of a liquid metal thermal transfer fluid, the pathway including a portion in close thermal communication with a pipe (703 - conduit);
- at least one electromagnetic pump (707 - electromagnetic pump) for motivating flow of the liquid metal thermal transfer fluid through the pathway away from and back to the pipe (see col. 8, line 43 - col. 9, line 5; Figure 7);
- wherein the pathway for transport of the liquid metal thermal transfer fluid and the pipe together define a heat transfer path away from the high power density device (see col. 8, line 43 - col. 9, line 5; Figure 7);
- wherein the high power density device is located in a folding device (see col. 9, line 24-34);
- wherein at least a portion of the liquid metal thermal transfer pathway traverses a bend in the folding device (see col. 9, lines 24-34);
- wherein the bend traversing portion of the liquid metal thermal transfer pathway includes a flexible conduit (see col. 9, lines 24-34);
- wherein the bend traversing portion of the liquid metal thermal transfer pathway includes a hinge that defines an integrated conduit therethrough (see col. 4, lines 59-65; col. 9, lines 24-34);
- wherein the liquid metal thermal transfer pathway includes a portion in close thermal communication with the high power density device (see col. 8, lines 43-47; Figure 7);
- wherein at least a portion of the liquid metal thermal transfer pathway is formed using a flexible conduit (see col. 9, lines 24-34);
- the liquid metal thermal transfer fluid (see col. 8, lines 43-47).

Regarding claims 16-21, Ghoshal et al. ('861) disclose a method comprising:

- transferring heat from the high power density device to a liquid metal thermal transfer fluid (see col. 8, line 62 - col. 9, line 5);
- motivating flow (707 - electromagnetic pump) of the liquid metal thermal transfer fluid away from and back to the high power density device in a closed cycle fluid pathway (703 - conduit) (see col. 8, line 43 - col. 9, line 5; Figure 7);
- transferring heat from the liquid metal thermal transfer fluid flow to a pipe (see col. 8, line 62 - col. 9, line 5);
- transporting the liquid metal thermal transfer fluid through a flexible conduit portion of the closed cycle fluid pathway (see col. 9, lines 24-34);
- transporting the liquid metal thermal transfer fluid through a bend traversing portion of the closed cycle fluid pathway (see col. 9, lines 24-34; Figure 7);
- wherein the bend traversing portion of the closed cycle fluid pathway includes a flexible conduit portion (see col. 9, lines 24-34);
- wherein the bend traversing portion of the closed cycle fluid pathway includes a hinge that defines an integrated conduit therethrough (see col. 4, lines 59-65; col. 9, lines 24-34).

Regarding claim 26, Ghoshal et al. ('861) disclose a method comprising:

- transferring heat from the liquid metal thermal transfer fluid flow to a pipe (see col. 8, line 43 - col. 9, line 5).

Ghoshal et al. ('861) do not expressly disclose:

- a heat pipe.

Ghoshal et al. ('861) further teach that it is well known in the art that heat pipes are used to extract heat from high power density devices dissipate the heat at another location (see col. 1, lines 54 - col. 2, line 5). Ghoshal et al. ('861) further disclose forced fluid cooling is an attractive option to cooling HPDDs. Further disclosed is that by circulating the forced fluid through the HPDD, the heat from the HPDD is carried away and dissipated at a sink placed at a distance (see col. 2, lines 21-36).

Regarding claims 4, 9 and 16, in view of this teaching, it would have been obvious to one of ordinary skill in the art to provide the system of Ghoshal et al. ('861) with the claimed heat pipe, in cooperation with the existing electromagnetic pump, as a means of transferring heat away from the high power density device (HPDD) because the heat pipe would allow for effective removal of the excessive temperature buildup that is generated by HPDDs through a means of forced fluid flow, thus decreasing the number of malfunctions, breakdowns and problems associated with interface resistance that occur in HPDDs.

Claims 19 and 25 meet the criteria set out in PCT Article 33(2)-(3), because the prior art does not teach or fairly suggest increasing and decreasing the bend of the pathway that the liquid metal flowing through.

Claims 1-26 meet the criteria set out in PCT Article 33(4), and thus have industrial applicability because the subject matter claimed can be made or used in industry.